SOYBEANS

Chemistry, Technology, and Utilization

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Chemistry and Nutritional Value of Soybean Components

The soybean is one of the most economical and valuable agricultural commodities because of its unique chemical composition. Among cereal and other legume species, it has the highest protein content (around 40%); other legumes have a protein content between 20% and 30%, whereas cereals have a protein content in the range of 8–15%. The soybean also contains about 20% oil, the second highest content among all food legumes. (The highest oil content is found in peanut, which is about 48% on dry matter basis. The third highest oil content is chickpea, which is about 5%. The remaining food legume species have oil contents in the range of 1–3.6%) (Salunkhe et al. 1983). Other valuable components found in soybeans include phospholipids, vitamins, and minerals. Furthermore, soybeans contain many minor substances, some of which, such as trypsin inhibitors, phytates, and oligosaccharides, are known to be biologically active. Others, such as isoflavones, are just being recognized for their powerful ability to prevent human cancers and other diseases (Messina et al. 1994, Chapter 10 of this book). In this chapter the chemical components of soybeans are discussed with respect to their occurrences, properties, nutritional value, physiological roles, and assay methodology.

I. Proximate Composition

On the average, oil and protein together constitute about 60% of dry soybeans. The remaining dry matter is composed of mainly carbohydrates (about 35%) and ash (about 5%). Since the water content of stored mature beans is usually about 13% to ensure storage stability, on a wet basis, soybeans contain about 35% protein, 17% oil, 31% carbohydrate, and 4.4% ash.

In general, cultivated soybeans comprise approximately 8% hull, 90% cotyle-

Table 2.1. Proximate Composition of Soybeans and Their Structural Parts

	Percentage in Whole Seeds	Chemical Composition (% dry matter)			
		Protein	Lipid	Carbohydrate	Ash
Hull	8	9	1	86	4.3
Hypocotyl axis	2	41	11	43	4.4
Cotyledons	90	43	23	29	5.0
Whole seeds	100	40	20	35	5.0

Source: Data adapted from Wolf and Cowan (1975).

dons, and 2% hypocotyl axis (Table 2.1). Cotyledons contain the highest percentage of both protein and oil, whereas the hull has the lowest values of these components. In fact, the oil content in hulls is so low that it can be regarded as a trace amount. The hypocotyl axis has a protein content similar to cotyledons but its lipid content is about half that in cotyledons. Since the cotyledon is the major component in the whole seed, its composition is very close to that of the whole seed regardless of great compositional differences among structural parts.

The actual composition of the whole soybean and its structural parts depends on many factors, including varieties, growing season, geographic location, and environmental stress. Liu et al. (1995a) reported that among the 10 selected soybean genotypes grown in Arkansas, on a dry matter basis, protein varied from 39.5% to 50.2%, oil 16.3% to 21.6%, and protein plus oil 59.7% to 67.5%. Among the lines in the U.S. germplasm collection, however, the range is even greater, with protein varying from about 30% to over 50% and oil from about 12% to almost 30% (Orf 1988).

Hurburgh (1994) compiled soybean protein and oil regional data from eight years of U.S. surveys and found that soybeans grown in the Western corn belt were consistently one percentage point lower in protein than soybeans grown in the remainder of the United States. There was year-to-year variability in protein patterns among regions also. Oil percentages were more variable than protein percentages among different years.

Drought and temperature also affect the chemical composition of soybeans. Dornbos and Mullen (1992) reported that severe drought increased protein content by 4.4 percentage points, whereas oil content decreased by 2.9 percentage points. As drought stress increased, as measured by accumulating stress degree days, protein content increased linearly and oil content decreased linearly at each air temperature.

II. Lipids

During seed development, soybeans store their lipids, mainly in the form of triglycerides, in an organelle known as oil bodies. In some literature, oil bodies

composition, interesterification generally increases crystallization tendencies (melting point) of fats and oils. Details are provided in Chapter 6.

Reports differ regarding the effect of fatty acid distribution within triglyceride molecules on oxidative stability. Some reported that when specific fatty acids occupy the 1 and 3 positions of a triglyceride, oxidative stability is greater than when those same fatty acids occupy the 1 and 2 positions (Neff et al. 1992). Others found that the positional distribution has no effect on oxidative stability (Park et al. 1983)

B. Phospholipids

Crude soybean oil contains 1–3% phospholipids. Among the total phospholipids in soybeans, there are about 35% phosphatidyl choline, about 25% phosphatidyl ethanolamine, about 15% phosphatidyl inositol, 5–10% phosphatidic acid, and the rest is a composite of all the minor phospholipid compounds. Figure 2.4 shows the molecular structure and formation of three major types of phospholipids found in soybeans. The parent compound is phosphatidic acid, which is not present in the free form in active cells except as an intermediate in the biosynthesis of other phosphoglycerides. Others are esters of phosphatidic acid.

Both triglycerides and phospholipids are saponifiable but phospholipids are polar lipids. Removal of polar lipids from crude oil is carried out by centrifugation following hydration at an elevated temperature, the process commonly known as *degumming*. Phospholipids are good emulsifying agents, soluble in alcohol and insoluble in acetone. In living tissues, they are the major components of cell membranes.

It should be emphasized that phosphatidyl choline's common name is lecithin. However, in broad usage, the term "lecithin" generally refers to the entire phospholipid fraction separated from soybean crude oil by degumming. Lecithin processing and utilization are covered in Chapters 6 and 7, respectively.

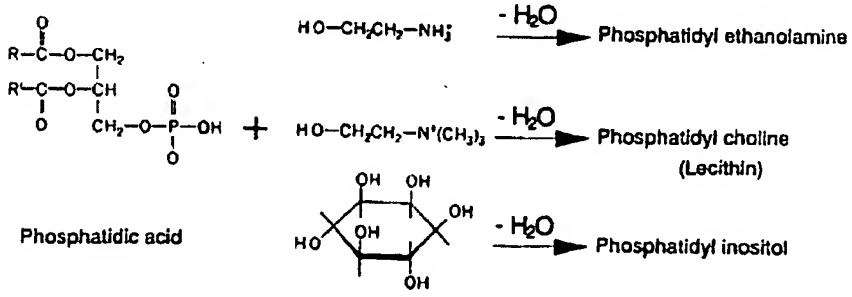

Figure 2.4. Molecular structure and formation of phospholipids commonly found in soybeans.